Ways of going on

Ways of Going On: An Analysis of Skill Applied to Medical Practice

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Humans do two types of actions, polimorphic actions and mimeomorphic actions. The ability to carry out polimorphic actions cannot be mastered outside of socialization. Mimeomorphic actions, however, can be learned in other ways; sometimes, they can be learned away from the context of practice. Polimorphic actions cannot be mimicked by machines, but some mimeomorphic actions can. Other mimeomorphic actions are too complex to mechanize. Actions that cannot be mechanized because they are physically complicated should not be confused with actions that cannot be mechanized because socialization is needed to master them. The analysis has implications for recent debates concerning the differences and similarities between humans and machines. The implication of the analysis is that much more can be understood about the relationship between humans and machines if the difference is treated as being a consequence of the unique properties of human societies. In this article, the analysis is applied to cardiac catheterization, pacemaker implantation, simulation of bodies, and work in a medical "SkillsLab."

What is skill? How is it learned? To explore these questions, we will discuss the transfer of skills and the way they are distributed within human societies and their artifacts.[1] We will take skills associated with medicine as our illustrative example. Much of our argument rests on the premise that the only *known* way to develop the appropriate responses to many of the changing situations that confront one in the flux of social life is by practice within social life. To put this another way, the only known way to become a socially competent entity is by going through a process of socialization. We will explore the significance of this premise. It will help us to understand which

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AUTHORS' NOTE: This work was in part supported by United Kingdom Economic and Social Research Council Grant No. R000234581.

Science, Technology, & Human Values, Vol. 22 No. 3, Summer 1997 267-285

skills cannot be transferred to humans outside of normal practice and help illuminate the role of apprenticeship (Lave and Wenger 1991). But we will also try to work out which types of skill can be learned with the use of simulators or models or in classrooms. We will also see which skills can be "delegated" to machines. Our argument rests on, and reinforces, the distinction between humans and machines. Crucially, until we learn how to build a radically different type of machine, humans alone will be able to reproduce those actions that can be mastered only through participation in social collectivities. Thus, recent claims that the separation of the domain of the human from the domain of the nonhuman should always be treated as "constructed" take the principle of symmetry too far and will lead us to fail to understand many aspects of the relationship between the domains.[2]

The premise upon which our argument rests—that many human skills can be learned only through socialization—may be wrong. A couple of decades ago, some psychologists and biochemists thought they were on the verge of discovering the chemical basis of knowledge. They believed they had found a chemical responsible for fear of the dark which enabled them to transfer this fear by injection. It seemed that incremental progress would lead to the discovery of chemicals such that swallowing a pill would give one knowledge proper or even enable one to become a fluent speaker of, say, Dutch.[3] As it happened, this line of research on knowledge-equivalent chemicals proved fruitless; if it had not, our premise could have become otiose. In the same way, developments in artificial intelligence (AI) may yet render the premise worthless, and it may be possible to produce a facsimile of a person with social competences without needing to embed the facsimile in society. We say only that such developments have not yet occurred. Thus, as of today, the only known or foreseeable way to become, say, a fluent speaker of Dutch is to interact socially with Dutch people in a way that no immediately foreseeable computer can.[4]

Polimorphic Actions and Mimeomorphic Actions

Having set out the preconceptions, the rest of the argument proceeds in two steps. The existing languages associated with skill, action, and machine behavior are often ambiguous or invested with connotations which are misleading from our point of view. Thus, we begin by describing a dichotomy of action which was introduced for the specific purpose at hand. We continue by showing the use and value of the dichotomy in the context of medical and surgical practice.

We will speak about humans having the ability to carry out both *polimorphic actions* and *mimeomorphic actions* (Collins 1990; Collins and Kusch 1995a, 1995b).[5] Polimorphic actions are typically carried out with different behaviors on different occasions. These actions can be mastered only through the embedding of the learner in the relevant social group. The coordination of polimorphic actions depends on the kind of understanding of the relationship between observable behavior and meaning that comes with socialization. For example, coordination of the actions of "paying" requires one to understand that passing coins across a counter and signing a check are both elements of the polimorphic action called "paying money." Likewise, it is necessary to understand that signing a check and signing a suicide note are parts of different polimorphic actions, even though the hand movements might seem identical. An outside observer who was not a member of the society in question would be unable to partition these various movements of parts of the body in a way that corresponds with their sense as actions.

In contrast, the archetypical example of a mimeomorphic action is the kind of "Taylorist" production-line work portrayed by Charlie Chaplin in the film *Modern Times*. The characteristic of mimeomorphic actions is that we always try to execute them with the same spatio-temporal behavior. The word "same," of course, needs a frame of reference. Thus, a golfer trying to "groove the swing" of the club is engaged in mimeomorphic action, but the most perfect swing would be seen as wildly varying by an engineer with a high speed camera and a micrometer. It is the golfer's perspective that we care about when we talk of mimeomorphicity; there is no doubt about what the golfer is trying to do.

If an action is mimeomorphic, then a description of the movements associated with the action can be captured in space-time coordinates. "Playing back" the space time coordinates through an appropriate robot will, as far as an outside observer can see, reproduce the action, even though the entity that reproduces it may be without relevant socialization. This is why it is possible to inscribe a formula for mimicking or reproducing a mimeomorphic action in texts, machines, and so forth. The rerunning of the instructions whether by a machine or by another human being who does not understand what he or she is doing will *mimic* the original action; if the human does understand what he or she is doing, he or she will *reproduce* the action.[6]

In the above sense, mimeomorphic actions are decontextualizable.[7] Their formulae can be inscribed in temporarily decontextualized form and transferred without loss between human contexts. It would, however, be wrong to conclude that the difference between the two types of action is simply the difference between what is "inside" humans and what is "outside." We can *internalize* the formula for a mimeomorphic action; one of the questions we will try to answer is how an internalized mimeomorphic action differs from a polimorphic action.

Actions contain other actions. A large-scale action—say, playing sport—embeds a smaller-scale action—say, playing golf. Playing golf in turn embeds swinging a golf club, which embeds swinging the 7-iron and so on. If we were to use a "tree diagram" to show how actions are embedded within one another, more polimorphic actions would be at the top of the tree and more mimeomorphic actions at the bottom, where actions "cash themselves out" as physical movements of the limbs and so forth. For technical reasons, mimeomorphic actions can be embedded in polimorphic actions, but mimeomorphic actions cannot have polimorphic actions below them.[8] It should also be clear that the way an action is described depends on the level at which it is approached. Sport is polimorphic action and so is golf, but lower down swinging a 7-iron is (often) mimeomorphic. It is also the case that the same activity can be carried out by humans in different ways. Thus, assembly-line work can be Taylorist and, therefore, mimeomorphic or far more flexible and polimorphic.

Learning Skills

We use the word "learning" to cover a variety of ways of acquiring knowledge and skills. Learning is often thought of as a conscious or active process; in our treatment, however, learning includes the acquisition of abilities that the learner is unaware of possessing.

Mastering Polimorphic Actions

Advice and instructions may aid the mastery of polimorphic actions, but the advice does not comprise a description of what is learned, nor can it replace experience. For a set of instructions covering a polimorphic action to be so complete that it could not be misunderstood by an unsocialized entity, it would need to anticipate all the social circumstance with which the skilled practitioner must cope. Neither advice which can be comprehended by humans nor the more complex "advice" which can be utilized by computers amounts to a decontextualized version of a polimorphic action.

Social capabilities survive, like oral cultures, within the continued social activity of those who practice them. Social capabilities cannot be "dried out," like soup, ready to be reconstituted when immersed in the proper social context; they cannot hibernate, only die. That is why skills and languages disappear—barring reinvention (MacKenzie and Spinardi 1995).

Learning Mimeomorphic Actions

The behavior associated with mimeomorphic actions, on the other hand, can be described and stored outside of a social context. It is tempting to think that this means that mimeomorphic actions can always be learned outside of social context too, but things are not so straightforward; we need to introduce a distinction between what is possible in principle and what happens in practice. Because humans have limited cognitive and physiological capacities, our ability to carry out certain actions in certain ways is limited even in cases in which no philosophical principle is at stake. Thus, if our brains were about the size of the universe, we could play perfect chess by following a set of rules covering each position on the board. We would then play chess as a very complicated mimeomorphic action. We cannot play chess this way. Many other mimeomorphic actions are in principle just matters of assembling behaviors, but, in practice, either the formulae have not yet been worked out or they are too complex ever to be worked out, or, even if they could be worked out, they would be too large to be comprehended.

Simple and Complex Mimeomorphic Actions

There are, then, simple and complex mimeomorphic actions. Learning the multiplication tables or basic military drill is learning a simple mimeomorphic action; humans can learn these by rote repetition or from instructions which can take many different forms. Thus, a printed multiplication table is a set of instructions that can be used by a human to learn the multiplication table and thereafter chant relevant passages from it as the need arises. (Note that this is not the same as learning to multiply.) The multiplication table can also be encapsulated in a computer program or a set of physical objects such as the components of slide rule. Humans can master and even "internalize" simple mimeomorphic actions which they may apply later within more complex sequences of polimorphic and mimeomorphic actions. The multiplication table is learned in the classroom and usefully applied outside the classroom, though polimorphic actions may be part of the application (pace Lave 1988).

In contrast, the rules contained even in an ordinary desktop chess computer could not be used by a human to learn chess because they are too complex. Another example of a complex mimeomorphic action, one that has caused great confusion because of its role as the paradigm of "tacit knowledge" (Polanyi 1958), is riding a bicycle across a traffic-free landscape. Though it might be possible to describe the physics of bike riding, including the feedback rules, in a series of equations, and even possible to translate these into prescriptions for balance and handlebar movement, knowing these formulae would not help the rider; a human cannot "apply the formulae" in order to ride the bike. Humans master the ability to ride bikes without being able to formulate the dynamics. But it is vital to keep this kind of ability separate from the human ability to perform polimorphic actions. One consequence of the fact that bike riding across a traffic-free landscape is a complex mimeomorphic action is that it can be mimicked by machine in a way that a polimorphic action cannot.[9]

The limitations of AI are the limitations of mimeomorphic actions. Any action that humans are prepared to carry out mimeomorphically can, in principle, be represented by the program of a computer. The limitations of "symbolic AI" are the limitations of those mimeomorphic actions that we can represent in formulae (a subset of all potential mimeomorphic actions). It is difficult to generate a set of instructions that represents a *complex* mimeomorphic action. It takes human programmers many person-years to write programs which can reproduce this complexity, even though, unlike humans, computers may be able to make use of them.[10] The "great breakthrough" made in the development of neural net computers is their ability to develop these formulae for themselves without humans having to provide the program first. But in spite of what some philosophers and AI enthusiasts think, this ability is not equivalent to mastering polimorphic actions.

If this argument is correct, while neural nets are an advance on previous AI techniques, they have not crossed a major boundary between human and machine competences.[11] We argue that the big step made by neural nets is the development of relatively easy methods for developing the formulae that describe complex mimeomorphic actions.

Simulation

It is, then, too difficult for humans to learn complex mimeomorphic actions away from the context of practice even when the equivalent set of instructions has been formulated. A solution can be achieved through the use of simulators (for example, aircraft cockpit simulators). Using simulators, humans do not learn complex actions as formulae; they learn them in the same way as they learn polimorphic actions—through practice. The problem with simulators is that to build them the designers must develop a set of formulae equivalent to the complement of the complex mimeomorphic actions that the learner has to master. This is just as difficult as building a computer to mimic the actions themselves. Thus, building an aircraft simulator is, in principle, something like building a very complicated autopilot. One can, of course, be lucky enough to find simulators already in existence. For example, animals are naturally occurring simulators for human beings where aspects of surgical training are concerned.

When simulation is not available, the only way for humans to learn mimeomorphic actions is through apprenticeship in the context of use. As we have said, even simple mimeomorphic actions *may* be learned this way. The fact that mimeomorphic actions are often learned in the same way as full-blown polimorphic actions makes it easy to confuse the two. The crucial point is, however, that polimorphic actions cannot be learned except through socialization or apprenticeship, while mimeomorphic actions can, sometimes, be learned in both ways.

The next step is to show how this schema applies in practice.

Two Types of Skill in Medical Practice

We have watched various types of surgical procedures. Drawing on our observations of cardiac catheterization and pacemaker implants in turn, we will illustrate the difference between simple and complex mimeomorphic actions on one hand, and polimorphic actions on the other. We have also watched the attempt to teach medical skills away from the context of use in a medical teaching laboratory—the Maastricht "SkillsLab"—and attended to progress in the simulation of body parts for medical skills training and progress in surgical robotics. These observations will be used to reinforce the argument.

A Simple Mimeomorphic Action in Cardiac Catheterization

In cardiac catheterization, which we observed in Maastricht's teaching hospital, a catheter is guided into the heart for diagnostic purposes. An artery is opened in the upper thigh, and the catheter—a thin, hollow plastic tube—is pushed and jiggled through the arterial system until it enters, for example, one of the chambers of the heart. The doctor pushes the catheter and guide wires into the artery, rotating it, wiggling it, and withdrawing and pushing again as it is painstakingly maneuvered into place. The procedure is aided by continuous X-ray imaging so that the progress of the catheter is visible on a television monitor. The patient lies on a platform that is easily slid from side to side and up and down, enabling the doctor to move the patient with respect to the fixed X-ray apparatus so as to obtain the proper view of the end of the catheter.

To the onlooker, there are a number of features of this procedure that seem to call for great delicacy and skill. For example, wiggling and pushing a plastic tube along four or five feet of blood vessels into the heart seems something that must take a great deal of time to master. How hard should one push? How does one ever dare to do it for the first time? This is a beating human heart that is being interfered with! Surprisingly, though, when we asked a doctor who was learning the trade what was the most difficult part of the procedure, he replied unhesitatingly that pushing the bed in the right direction so as to obtain the correct X-ray image caused him the greatest problems.

> It is still the most difficult [aspect] for me. The problem is, you have different views. You have to go backwards or downwards—to the head or away from the head. . . . I still make mistakes sometimes when I have to get the table towards me or away from me.

To the doctor, the bed seems to have to be moved the wrong way. It is as though the X ray shows a mirror image.

Now, assuming normal bed-moving has been mastered (and controlled pushing and pulling is the kind of mimeomorphic action one learns very early in life), the additional element in the procedure—moving the bed the wrong way—is simply an adjustment to the pattern of the mimeomorphic action. There are no social aspects to the skill; there are not even the complex aspects associated with the pushing and wiggling of the catheter into the arterial system.[12]

The bed-pushing part of the skill could be taught well away from the operating theater with a simulated setup. A doctor could master it without ever going near a patient. If the doctor did master the skill of pushing the bed in the mirror-image direction so thoroughly that it required no more conscious thought than pushing the bed effortlessly in the "right" direction, he or she would merely have internalized an additional set of behaviors that could be exhaustively described by an algebraic formula. Not unrelatedly, it would not be hard to design a mechanical linkage or an electronic device to overcome the problem without the surgeon having to learn new abilities. Speaking loosely, we might be inclined to refer to such an ability as a "situated" skill because every operation is different, but this is to miss important distinctions. Seeing the distinctions, one is led straight to an element of the procedure of cardiac catheterization that could and should be taught away from the theater and could and should be mechanized with existing technology. One can also see what might be simulated in the longer term.

Interestingly, we have recently heard that mechanization of a similar process is taking place in the field of abdominal laparoscopy. "Keyhole surgery" on the stomach requires the surgical team to control at least three manipulators which are inserted through small holes in the stomach wall. The surgeon usually works with two devices for cutting, sucking, stitching, and so forth, while an assistant controls the telescope which projects an image on a television screen offering visual feedback to the surgeon. The surgeon has to give verbal instructions to the assistant. Here is how one British consultant described the problem:

> [T]he assistant . . . has to obey the commands of the surgeon, and, for instance, there can be a problem with the left to right movement, because obviously a left movement of the camera will produce a right movement of the image on the television screen—it's the mirror image effect. And, although this can be learnt, this is an initial problem certainly. And actually, I say to my assistants, "move your hand to the right a bit and your hand left a bit," and I take it on myself, and er . . . so long as they actually do what I want them to do, then there isn't a problem. But, you know, sometimes they think, when you say "hand right a bit," you mean "image right a bit," and do it the other way, so you can't win.

This problem is being resolved by the introduction of "Laparobot," a device which moves the laparoscopy telescope by appropriate translations of sensed movements of the surgeon's head. To quote the same source, "the surgeon . . . therefore has total control—when he moves right, the image moves right, and when he moves left . . . The zoom is a forwards movement of the head."[13]

Polimorphic Actions in Pacemaker Implantation

Pacemaker implantation was observed in Bath's Royal United Hospital. A heart pacemaker is a metal box about one centimeter thick and four centimeters square. It is implanted into a pocket cut in the fat beneath the top left part of the chest, between the shoulder and the breast. One or two electrical leads go from the pacemaker into the chambers of the heart. It is the routing of these leads that concerns us. The surgeon's first job is to find a route for the electrode(s) from the intended site of the pacemaker into the heart. There are two possibilities. The route favored in the Bath hospital is via the cephalic vein, which lies in the trough below the left shoulder between the shoulder muscle and the chest muscle. The alternative route is via a blood vessel which runs vertically down into the heart from beneath the clavicle.

This vessel is much larger and easier to find; using it, the leads can be guided to the heart in a few minutes of manipulation. There is, however, a greater risk of puncturing the heart wall in using this route. It is for this reason that the cephalic route is preferred in Bath, though it was explained that in other hospitals the "subclavian puncture" was always used because its slight extra risk was thought to be offset by its speed and efficiency, with consequent reduced risk of infection and reduced period of discomfort for the patient. Even if the surgeon sets out to use the cephalic vein route, the subclavian puncture is held in reserve in case of failure. The initial incision and dissection are the same for either route.

The procedure begins with a horizontal cut four to six centimeters long in the hollow part of the chest below the left collar bone. Now the surgeon has to begin cutting through layers of fat, delving down through the muscle and muscle sheath (fascia) to try to find the trough between the muscles within which the cephalic vein nestles. The following comments were made by a surgeon describing the finding of the cephalic vein:

> You see that little bit of fat there, that white stuff? . . . That little row of white stuff. That's the surface of the cephalic canal. You have to sort of open up inside really. And the vein should be under there. . . . I think I've spotted the vein. Come and have a quick peek. It's fairly oozy. That's the fat pad at the roof of the canal there. The vein is just underneath it. It's awfully oozy. Get some more swabs.

When the vein has been located, a hook-shaped "needle" is passed beneath it, and the vein is lifted and tied in two places so that about an inch is exposed and clear for work. The surgeon must then nick into the vein with a scalpel to make a hole into which the electrode, perhaps 30 to 40 centimeters long, can be inserted and guided to the heart. The vein is sometimes very hard to find. Some patients bleed so much that the view is obscured. Some patients—especially women—have a thick layer of subcutaneous fat, which means that the vein is too deep to be found or, if found, too deeply seated to manipulate. Sometimes, the vein is very small—too small to allow an electrode to penetrate. Sometimes, other things go wrong. In such cases, the cephalic procedure is abandoned and the subclavian puncture is used instead.

The cephalic route is successful in about 70 to 80 percent of occasions. Collins watched five such procedures, however, and on each occasion but one, the cephalic vein route failed. In the first case, the vein was found easily, but the electrode could not be made to penetrate—seemingly due to venal spasm. Eventually, the vein was too damaged to continue. The surgeon had cut too far through it in his attempt to make a hole big enough for the electrode. In the second case, the patient was too fat. After cutting down through layers of fat to a depth of about four centimeters, it became clear that even if the vein was found, it would be too deep to use. On the third occasion, the vein was found and opened, but, for unknown reasons, the electrode could not be pushed into it. On the fourth occasion, though the patient was thin, the vein simply could not be found. (In each of these cases, the procedure was rapidly and successfully completed via the subclavian route with no harm to the patient.)

Pacemaker implantation begins with cutting and delving into the human body. At least part of learning the skill of flesh manipulation is learning a complex mimeomorphic action. According to our argument, it could be learned away from the context of use but only via simulation. In fact, surgeons may begin to master flesh manipulation by working on cadavers or animals, though the simulation is far from perfect. Thus, a surgeon remarked,

> DW: Oh no, no. Dissections [on cadavers] are all very well but they don't dissect properly, they don't act like normal human tissues. It's not the same thing at all. It doesn't feel right when you're doing it.
> HC: What about working on animals?
> DW: Well, animals, I suppose they feel right but I've not really done much. I haven't done much in the way of research since I've left university. Animals, I think, yes it does feel that the tissues have the same sensation but of course the anatomy's completely different. What you gain there you lose.[14]

It is worth noting that this problem does not arise currently in the case of veterinary surgery in which surgeons do practice on animals that are not the "real thing." The "real thing" in veterinary surgery is often defined by the economic value of the animal. The veins and bones of expendable animals make perfect simulators for the veins and bones of expensive animals. Surgeons working on humans, however, must find out how to do this part of the work largely by working with flesh and veins rather than a substitute.

There are, however, social changes which are causing more use of simulation away from the operating theater even in the case of training for flesh manipulation. First, the animal rights movement is making it more difficult to use animals in the training of both human and veterinary surgeons. Second, as a result of financial and managerial changes, small-scale surgery on humans (in Britain, at least) is beginning to be carried out by a wider group of less intensively trained general practitioners, working in their own consulting rooms. It is easy to see that skills such as suturing can be practiced on flesh substitutes, but nowadays it is possible to practice internal examination on artificial torsos (as we witnessed at the Maastricht SkillsLab), injecting, lancing, burning, freezing, breast palpation, and so forth on simulated body parts which are realistic to the touch (as developed by general practitioners in the Bath area), and internal surgery on the simulated internal organs of animals (as seen in Cornell's veterinary school). One day, perhaps, most of the skill of cardiac catheterization and flesh manipulation will be learned on simulated bodies. The analysis put forward earlier in this article makes sense of these developments.

There is, however, another aspect to pacemaker implantation (and surgery in general) which cannot be fully encompassed by the idea of a mimeomorphic action, however complex. Consider what is involved in the surgeon's decision about whether and when to stop the cephalic procedure and move to the subclavian puncture. When does the surgeon decide that the cephalic procedure has failed? How does he or she decide that it is time to stop searching for the vein or that the layers of fat are too deep to work with? Again, an extract from a conversation helps to illustrate the problem.

> HC: How do you make the judgement about how long to go on before it's time to abandon . . .
>
> WH: That's difficult. It really depends on the patient. . . . You can tell. . . . You start to tell. The patient gets a little bit distressed and restless . . . and once you start to see the signs that the patient's getting restless you know you've got to finish within twenty minutes. Or give them sedation.
>
> HC: Is that the anaesthetic wearing off or is it just that the patient's sort of had enough?
>
> WH: No, I think that's the patient's tolerance level. You know, you've been fiddling around. Although it's not painful, I mean, you have to sit still, you're gowned up, there's a level of anxiety. . . . It's the immobility more than anything that patients don't like after about an hour. And then when the elderly . . . well their bladder starts to fill up a bit.
>
> HC: So it's all a matter of judging it on the individual patient.
>
> WH: Yes. Some patients come down here after having had their pre-med, absolutely out cold. You could operate for hours and they'd never notice anything.
>
> WH [Aside, to patient]: You alright under there? It's alright, you just keep still now, we're just putting the last stitches in. [Presses flat of palm onto patient's nose.] Just making sure enough blood's going round. Soon be done—alright?

The surgeon's last remark to the patient is not irrelevant to our argument. The patient is under a local anaesthetic only, and the degree of distress suffered depends, to some extent, on the surgeon's bedside manner. The surgeons tend to make occasional comforting remarks to the patient, to keep them relaxed so that they are able to continue a procedure longer than might otherwise be possible. The general state of tension in a patient also affects the state of the tissues. For example, venal spasm might be due to a patient's tension or distress. Thus, the decision to terminate the search for the cephalic vein is partly a function of the patient's distress, but the distress is itself partly a function of the surgeon's skills in creating the right sort of environment for the operation.

But there is more than the situation of the individual patient to be recognized and created. The decision is truly made within the form of life of the hospital and the society as a whole. What counts as distress? How much distress should a patient be allowed to suffer? How much responsibility does the surgeon have for complications that might arise out of an overextended procedure? What is the social relationship of the patient to the doctor? What is the financial relationship? (These conditions might be different under different medical funding regimes, under different legal regimes, in a military field hospital, and in veterinary surgery.) What is the relationship between the moral, social, legal, and medical cost of one kind of complication—distress and infection—compared with the other kind of complication—puncture of the heart wall? Getting these things "right" is a matter of sharing a form of life, a form of life that a doctor learns as he or she learns the social life of the hospital. It is essentially a matter of embodiment within a human society and most certainly not a matter of acquiring the skills associated with mimeomorphic actions.[15]

Simulating Social Settings?

Can polimorphic actions be learned through simulation? The SkillsLab at the medical school of the University of Limburg in Maastricht tries to teach the elements of medical skills without exposing students to real patients. The SkillsLab uses increasingly sophisticated simulators. In successive attempts to learn a skill, students start on models, then practice on fellow students, then on simulated patients, and finally on real patients with relatively stable dysfunctions.

This succession of more and more realistic simulators can teach complex mimeomorphic actions. Such training is especially effective when people with already diagnosed physical abnormalities agree to act as stand-ins for real patients with similar physical abnormalities. In one sense, this last form of training employs models that are more "real" than simulated.

A "fault tree" model underlies this kind of training despite the "reality" of the symptoms. The simulating patients have to know the fault tree just as well as the students. Otherwise, they would not know how to pretend to be ill in just the right way. Even the model patients with genuine physiological problems are ideal types, chosen and trained so that they clearly exhibit symptoms associated with an officially diagnosed illness. One might say that they are "walking textbooks."

Working with an undiagnosed pathology, with less stable and clear-cut symptoms, outside of the supporting environment of a training school can be a very different matter. When a proper diagnosis is a matter of life or death, the stress attending the doctor's examination cannot be reproduced in the SkillsLab. A SkillsLab patient is not being examined for the first time. Nor are the simulated patients calling the student out in the middle of the night for some trivial complaint.[16] Nor is the examination conducted on a querulous and lonely elderly person for whom a visit to the doctor is an outing or the only opportunity to chat in the course of a lonely week.

Thus, even the interpersonal training that takes place in the SkillsLab teaches a set of complex mimeomorphic actions. It is a scaffolding of phrases and behaviors upon which real-life expertise may later be erected in the hospital or the consulting room.

The SkillsLab is a success story. Not only is it being emulated elsewhere, but the students love the opportunity to don the persona of a medical practitioner with all its symbols, apparatus, and seeming power and responsibility. Nevertheless, the doctors into whose hospitals these students were transferred for postgraduate training agreed that only some improvement in training had been made. The students themselves soon realized that they had learned a great deal less than they had imagined. There is much to be said for learning mimeomorphic actions in a simplified environment, that is a useful element of training, but a simplified society does not serve to socialize one into a complex society, nor does a simplified culture enculturate one into a complicated culture.

Conclusion

Our analysis turns on the distinction between polimorphic actions and mimeomorphic actions. Although it is related to the dichotomies belonging to other philosophical discourses, the distinction we draw is slightly different. Such grand distinctions as between action and behavior, intention and cause, tacit and propositional knowledge, pre-predicative and predicative experience, situated actions and plans, being-in-the-world and thinking-about-the-world, socialization and instruction, and mind and body, split the world in the same spirit but tend to lump together everything that is internalized, intentional, and situated, as opposed to everything that is external, extensional, and physical. One difference between the new dichotomy and the old ones is that mimeomorphic action is intentional human action, often highly valued, but it is also a special kind of human action that can be expressed formulaically and mimicked by a human or a machine following a set of space-time coordinates. Thus, it cuts across each of the old dichotomies.

And what of the recent tendency to eliminate dichotomies? If our analysis turns out to be of use, it will have significance for philosophical treatments which insist on extending the "principle of symmetry" into the dichotomy between humans and machines. Extending the logic of symmetry may show that all dichotomies can be deconstructed, but this can obscure rather than clarify our understanding of the interactions between entities. Carrying out polimorphic actions is a capability of socialized human beings which cannot be mimicked by known or foreseeable machines. On the other hand, humans can choose to act in the fashion of machines; they can choose to act mimeomorphically. Thus, the distinction between polimorphic and mimeomorphic is a deep one. Moreover, societies can change the way they carry out many actions and, in doing so, can change themselves. For example, a social group may move from a polimorphic toward a more mimeomorphic style of, say, writing, to make it easier for computers to interact with documents. Such changes are changes in the texture of our actions and in our forms of life; they are social and historical changes which can be understood only if the difference between the human and the nonhuman is appreciated.

Notes

1. The work grows out of Wittgenstein-inspired sociology of scientific knowledge. See, for example, Bloor (1983), Wittgenstein (1953), Winch (1958), and Collins (1985). Both Wittgenstein and Winch see conceptual structures as the counterpart of patterns of activity within forms of life or, as we might say, social collectivities. Given this way of looking at things, investigating the way that people do things is investigating the way they think about the world, and vice versa. (This way of reading these authors does not correspond with every exegesis but is a fruitful reading for research in social sciences.) The sociology of scientific knowledge has taken this reading and applied it to the analysis of scientific theorization and experimentation.

2. For further discussion of this point, see DeVries (1995) and the arguments and counter-arguments of Callon, Collins, Latour, and Yearley, on pages 301-89 of Pickering (1992).

3. See, for example, Travis (1981).

4. This claim leads us immediately to the question of whether computers can yet pass the Turing Test. Our argument rests on the view that they cannot pass a properly designed test. For discussion of this point, see Collins (1990).

In earlier discussions, learning to act in a socialized way through being socialized has been called the "enculturational" model of learning. This was opposed to the "algorithmic" model, according to which knowledge could be transferred through assemblages of information. The main argument of these earlier discussions was that the algorithmic model could not deal with crucial aspects of knowledge transfer. Even in the hard sciences—the argument was initially exemplified with case studies of laser building and the detection of gravity waves—crucial aspects of knowledge transfer had to take place through a process of enculturation (see, for example, Collins 1985). In this article, the role of algorithmic knowledge transfer is resurrected; we show how it fits with enculturational transfer, while never losing sight of the role of enculturation.

5. These terms replace the "regular actions" and "behavior-specific actions" which were used in Collins (1990). It has been suggested that the old terms are not sufficiently "intuitive"; they do not carry enough information and do not contrast clearly enough to be memorized and easily applied. In the new terminology, the prefix "poly" connotes "manyness," referring to the many behaviors that must correspond to a polimorphic action, but we have used the pun "poli" to connote that the appropriate behavioral shape of such an action has to be determined by reference to the society (polis). In contrast, mimeomorphic actions can, in principle, be executed by copying the behavior that corresponded to a previous occurrence of the action.

6. The following revealing question was asked by Olga Amsterdamska: Suppose a robot followed its owner about mimicking everything that he or she did. If the robot was successful, showing that every action that the person did could be mimicked by a machine, would this show that every action the person did was mimeomorphic?

The answer is as follows. We describe machines as "mimicking" actions rather than acting so as to make clear that entities that do not have intentions do not act. When we say that a machine mimicks an action, we mean that the consequence of the mimicry is the same as the result of the action. There is, however, another use of the term "mimic." The type of robot mentioned in the query mimics the behavior, but its consequences are not necessarily the same as the results of the action. This is not surprising in the case of polimorphic actions. For example, if the robot's owner greets a secretary with a cheery "hello" and the robot immediately repeats the greeting in the same tone of voice with the same gestures, this is likely to be seen as mockery rather than greeting. To copy the behavior associated with the action of greeting—which means having it carried out twice, not once—is not to mimic the action. (There are a number of alternative analyses possible: perhaps a low-level action is being mimicked—"saying hello"—whereas the higher-level action—"greeting"—was not.) The same considerations apply to mimeomorphic actions in which a double execution does not have the same value as a single execution. Mimicry of behavior is often used as mockery by humans, and it matters not whether the action corresponding to the behavior is polimorphic or mimeomorphic. We conclude that not all copying of behavior, even in the case of mimeomorphic actions, is mimicry of the action. Nevertheless, no action can be mimicked by copying the behavior unless it is a mimeomorphic action.

7. A comprehensive theory of mimeomorphic action has to take into account what we call "disjunctive mimeomorphic actions," which allow that an actor may respond in different but preplanned ways to a prespecifiable set of contexts (Collins and Kusch 1995a, 1995b). Complicated disjunctive mimeomorphic acts may include preorganized responses to a previsualized range of circumstances—that is, feedback.

8. This is because mimeomorphic actions are defined as those which "cash out," at the bottom of the tree as identical behaviors; if a polimorphic action were to appear below a mimeomorphic action, then different behaviors would be allowed at the bottom of the tree. The theory, though inspired by Davidson's (1982) treatment of action, is not the same as his. For example, we do not believe that there is only one action—the physical movement—which comes under many descriptions. In our treatment, higher-level actions are just that; they are not simply redescriptions of lower-level actions. These features of the analysis rest on the work of Collins and Kusch (1995a, 1995b).

It is tempting (as one of our referees suggested) to try to map polimorphic actions onto "social actions" as defined by Max Weber among others. This misses the point that mimeomorphic actions are social actions too and are other directed. We are arguing that there is one class of social action that can be mimicked by machines and another that cannot. When action is mimicked by a machine, it is not, of course, other directed, but this makes no difference to the outside observer. As far as we can see, the dichotomy of actions we develop maps onto no other preexisting dichotomy however much it looks as though it is going to.

9. A Japanese self-balancing model bicycle is known as "Gyrostar" (see "Gyrostar" 1992).

10. The set of mimeomorphic actions that humans can actually carry out is larger than the set they can formulate. But there is a larger set which they could carry out if their brains were bigger and faster. Computer "brains" are bigger and faster than human brains when it comes to symbol manipulation. Therefore, symbol-manipulating computers can do more mimeomorphic things than humans so long as the formulae have been worked out.

11. There are various arguments that support this view: neural nets learn only by Skinner-type stimulus and response, whereas humans (which are the most powerful neural nets we have) are unable to gain the full range of human competences by this method alone; neural nets are not connected into society in the way that humans are—neural nets are isolated individuals; once they have finished learning, the contents of a neural net can be translated into a standard digital program and so forth. (See Collins 1996 for a reprise of some of these arguments).

12. Each arterial system is unique, but the procedure for catheterization could be described as a set of functions. Wiggling the catheter along the arterial system is, according to our full-blown theory (Collins and Kusch 1995a), a casual disjunctive mimeomorphic action.

13. A description of the device may be found in Ornstein and Finlay (1994). Medical robotics is a rich field for the study of the transfer of skills from human to machine.

14. We have also heard it argued that the skin and muscle tone of an animal are so different to those of a human that they do not make good simulators for humans.

15. None of this is to say that the choice of cephalic vein could not be "bureaucratized" and turned into a mimeomorphic action. We wish to say only that currently it is not and that mechanizing this choice would not leave the action unchanged. Thus, our argument has an implication for the increased tendency to follow carefully designed "protocols" in medical interactions. While following a preset protocol may lessen the risk of malpractice litigation, it is likely to be disadvantageous to the well-being of patients who are in the care of those doctors and surgeons who do have the skill to respond flexibly to circumstance.

16. In Britain, general practitioners have complained about being called out in the early hours to fix such things as a blocked drain!

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